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CACTI

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DAVID GRIFFITHS

Senior Horticulturist, Office of Horticultural Crops and Diseases
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and

CHARLES HENRY THOMPSON

Formerly Assistant Botanist, Missouri Botanical Garden

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INTRODUCTION

Popular interest in cacti appears to be periodical. Prior to and during 1912 there was a demand for information on this group of plants, but since 1915 there has been a quiescent period until during the last year or two, when there has been a revival of interest which bids fair to become increasingly important. Already cactus collections are being assembled rather numerously, and high prices are being paid for choice specimens. The horticultural trade journals are beginning to reflect the interest, and advertisements of new companies and new collectors are appearing. How far the movement will proceed can not be foretold.

There is a large cactus flora in the United States, and these materials are the ones now most prominently employed. The restrictions on the importation of plant material from Mexico, the cactus region par excellence, may have a decided influence on the development of the business. The interest in cacti is by no means confined to the United States. Already European nurserymen are inquiring about sources of supplies of seeds, cuttings, and plants in quantities. On account of the 10 or more years of comparative neglect, there are no commercial collections of importance. The collectors get what is available in their immediate sections and have little else to offer. The fanciers' collections must consequently be laboriously assembled from widely varied sources.

[1] This circular is a revision and enlargement of Bureau of Plant Industry Bulletin 262, "Ornamental Cacti: Their Culture and Decorative Value," which was published in 1912 but has not been available for more than 10 years.

With the exception of species of Rhipsalis the cacti are strictly indigenous to the Western Hemisphere. The introduction of these plants into Europe evidently began soon after the discovery of America. The English, Dutch, and Spanish traders, who early carried on a commercial business in the West Indies, South America, Central America, and Mexico, took back to their respective countries many interesting and curious plants then new to the gardens and plant lovers of Europe.

In the earliest published reports of the introduced and cultivated plants of European gardens accounts and in many instances illustrations of cacti are frequently found. Additional plants gradually were introduced, until at the time Linnaeus published his Species Plantarum (*13*)[2] he recognized 22 species, all of which he included under the generic name of Cactus. They were commonly known as thistles, probably from the spiny character of their protective armor. The smaller, more or less globose forms were called melon thistles, whereas the taller ones were called torch thistles or candle thistles. The Indian fig (*Opuntia ficus-indica*) and several other species of Opuntia were introduced into the Mediterranean region at a very early date.

From the time of the cited publication by Linnaeus the steady introduction of new plants was continued from the Western Hemisphere into Europe. These importations included many forms of cacti. Miller (*14*) enumerates a number of species distinct from those recognized by Linnaeus. Others were described and published from time to time by Haworth (*5*, *6*, *7*), Link (*12*), Salm-Dyck (*19*, *20*, *21*), De Candolle (*2*, *3*, *4*), Lemaire (*9*, *10*, *11*), Pfeiffer (*15*, *16*, *17*), and others. The most extensive modern systematic works are by Schumann (*22*) and Britton and Rose (*1*).

It was not until within the last half century that any special interest in cacti was manifested in North America. A few species, such as the night-blooming cereus (*Selenicereus* (*Cereus*) *grandiflorus* and *S. pteranthus* (*Cereus nycticallus*), queen-of-the-night (*Phyllocactus acuminatus*), crab cactus (*Zygocactus* (*Epiphyllum*) *truncatus*), and the rat-tail cactus (*Aporocactus* (*Cereus*) *flagelliformis*) had become favorites as house plants. General collections of this group of the plant world by George Engelmann laid the foundation for the large collection at the Missouri Botanical Garden at St. Louis, Mo. Similar interest manifested by Asa Gray added materially to the collection at the botanical garden at Cambridge, Mass. As the public became more acquainted with these bizarre forms of vegetation, a livelier interest in them sprang up, and many persons throughout the country began to gather private collections. Fanciers became so numerous that in certain localities clubs or societies were organized, where ideas and experiences as to the culture of these plants could be discussed and specimens exchanged. Experience was the high-priced teacher from whom these collectors had to gain their knowledge. Similar organizations were formed in Germany, where amateur collectors were numerous, and also in France and in England. Many articles have been published in the horticultural journals of these countries describing proper methods of propagation and culture, and William Watson, of the Kew Gardens, England,

[2] Reference is made by number (italic) to "Literature cited," p. 24.

issued a handbook of cactus culture (*23*). These helps have disseminated a better knowledge of methods to be employed, but the soil and climatic conditions of Europe differ so materially from those of various parts of North America that their rules are not well adapted to our own special needs.

Cacti are now widely distributed in tropical and warm-temperate regions throughout the world. They have become particularly abundant in portions of Australia, South Africa, and India. In Australia, especially where the hot and wet seasons coincide, certain species of Opuntia (mainly of South American origin) have taken possession of large areas. The prickly-pear nuisance there has become a national problem, baffling the resources of the Government. The problem may not be solved until the increase of population transforms the princely pastoral holdings into cultivated fields.

The growing interest in this group of plants in North America and the inadaptability of rules for general gardening in growing them, as well as of rules laid down for their special care by European growers, have created a demand for a work that will include both general and special rules that may be applied in any part of our country. To meet this demand is the purpose of this bulletin. Naturally, some of the material herein contained is compiled from the experiences of others, but use of it is made only in so far as it agrees with the experiences and observations gained during the years spent in caring for the collection at the Missouri Botanical Garden, in studying the plants in their native haunts throughout the Southwestern States and Mexico, in examining many private collections, and in growing collections under natural conditions in both Texas and California.

PROPAGATION

FROM SEEDS

Most cacti yield seeds abundantly. Ordinarily, in this country, few of these seeds germinate and develop into mature plants because of unfavorable environment. The seeds are usually fertile, however, and, when planted under proper conditions, a large percentage of them will germinate and with a little care will produce mature plants.

The best soil for growing cacti from seed has proved to be a thoroughly decomposed sod mixed with at least its own volume of sand. After these ingredients have been carefully mixed they are run through a sieve of about ¼-inch mesh, which removes any large particles and all superfluous root fibers, making a loose soil which drains readily. It is not necessary that the soil be rich in humus, and manured soils should always be avoided because of their undue tendency to hold moisture. They are also a medium for producing germs of decay. An open, drainable soil is the chief requisite for cultivating cacti.

For germinating the seeds an ordinary 4-inch pot is very convenient. New pots are preferable, but old pots may be used with safety if thoroughly sterilized. Porous pots are soon covered with green algae when left in a moist place for any considerable time. This growth will spread over the surface of the soil in a close blanket which precludes the free access of air and seriously retards the

drainage of superfluous water. These algae will in time grow over the little seedlings that have survived other adverse conditions and will smother them. To combat the algae the pots should be thoroughly sterilized just previous to being used, and to accomplish this object two efficient methods have been employed. One method is to bake or burn the pots so that all life on them or in their pores may be destroyed. The other method is to soak the pots for a time in a weak solution of copper sulphate and then thoroughly wash them. If a very strong solution of the copper sulphate is used, some of it will be left in the pores of the clay, and later when the seedlings are being watered enough may pass through the soil to injure the tender young plants.

Reasonable care should be exercised in preparing the pot for planting. As a rule, the drain hole in the bottom of the pot is too small and is easily clogged. This hole should be enlarged, as thorough drainage must be maintained in growing cacti. The pot should be filled to one-fourth its depth with small bits of broken pots, and on these the prepared soil should be placed and pressed or shaken together firmly but not packed hard. The soil surface is then leveled by the use of a round, flat-faced tamper of a diameter to just fill the pot. The soil should not be packed but should be lightly tamped, with only sufficient effort to produce a smooth, level surface. This surface should be about half an inch from the top of the pot. Over it the seeds are evenly distributed and then covered with a very thin layer of soil, upon which is spread a layer of fine gravel to a depth of about one-fourth inch. This layer of gravel is important in many ways. As the pots are later watered with a fine spray, it prevents the surface of the soil from washing and consequently keeps the seeds from being disarranged. It also promotes the free passage of moist air through the spaces between the bits of gravel, which, together with the shading by the gravel, prevents the surface of the soil from becoming dry and baked. It also checks the growth of algae over the soil surface.

As the seedlings grow they easily force their way through the gravel to the sunlight. For the first few months of their existence, cactus seedlings are but small, globular, balloon-shaped or cylindrical bodies, composed of very thin-walled cells filled to turgidity with water. They are so tender and delicate that they readily "damp off" if subjected to a sudden change from a high to a low temperature. The death rate of seedlings from this cause has been greatly minimized or almost wholly checked by the use of the gravel over the surface of the soil. This layer, with its intervening spaces, acts as a protection from sudden changes in temperature during that period of their growth when the seedlings are most susceptible to injury. By the time they have grown sufficiently large to project beyond the gravel they have become hardier and more robust in structure. Again, the gravel layer is of great value in that it keeps the surface of the soil moist. The little seedlings have exceedingly fine and delicate roots which spread out near the surface of the soil. If this surface is allowed to dry out to the depth of one-eighth inch or more, these delicate rootlets will be destroyed and the seedlings will be damaged or killed. In most instances the diminutive plant has not enough food stored up in its body to keep it alive until

OPUNTIA BRACHYCLADA

Section of plant and two buds. (Natural size.) The group to which this species belongs contains some of the most handsome as well as the most common prickly pears in fanciers' collections

another set of feeding roots can be produced, and it starves. For watering, a vessel should be used that gives a fine, gentle spray, in order to avoid the danger of washing the seeds from their position or of injuring the delicate young seedlings. Watering should be done at least once a day. The temperature of the propagating house or frame should be kept as nearly uniform as possible and should not vary much from 70° F.

The proper time for transplanting the seedlings differs for different genera and species, but they should usually be left in the germination pot until the plant shows at least three or four clusters of spines, except the prickly pears, which can usually be moved as soon as the seed leaves have expanded. By that time the tissues will have become considerably hardened, and a very good root system will have been formed. The taller growing species, such as Cereus and Opuntia (pl. 1) will be the first ones ready for transplanting. Mammillaria and kindred genera and plants of similar growth will be the last. The seedlings should be transplanted into a flat sufficiently small for convenient handling, which should be provided with drainage openings in the bottom. It should be filled with the same kind of material and soil as those used in the germination pots, the surface to be carefully leveled in the same way. The rows should be about an inch apart, with the same interval between seedlings in the row. After the flat has been filled with the seedlings, a thin layer of clean, fine gravel should be placed all over the soil surface and close up around the plants. The flats should then be placed in a perfectly level position, so that the soil will not shift from one side toward the other when watered. With the exception of Opuntia, cactus plants are mostly of slow growth and may remain in the flat for several months before being potted. The proper time for potting is when the plants have grown so large that they begin to crowd each other or when the roots of adjacent plants begin to intermingle. In preparing pots for individual plants the same method should be followed as for the preparation of the germination pots, except that a coarse soil may be used to advantage. It is not advisable to begin with pots smaller than 2½ inches, as they dry out too rapidly.

VEGETATIVE PROPAGATION

Almost all cacti may be readily propagated from cuttings. The plants are so soft in tissue and so filled with water that any bruise or mutilation is likely to be the point of attack of a rot which quickly destroys them; so, in making the cutting, a clean, sharp knife must be used and a smooth surface left on the cut end. The cutting should then be placed in a dry atmosphere for a day or more, until, by drying, a kind of cuticle has formed over the cut surface. It may then be rooted in sand on a bench or planted directly in pots. In the warmer, drier regions it may be placed directly in the open ground, provided the soil has perfect drainage. In greenhouse culture it is best not to place much of the cutting below the surface of the soil or sand; 1 inch is sufficient for large plants and less than that for smaller ones, in proportion to the size of the piece of plant used. When the cutting is long and likely to fall over, a stick should be inserted in the soil by its side and the two securely tied together until

roots have been formed. When mature plants are shipped in from the field the roots are always more or less injured. It is always best to cut away the roots, let the wounds dry and heal for a time, and then plant.

Many of the opuntias are naturally adapted to vegetative propagation. The stems are readily detached at the joints. These stems fall to the ground and in a short time develop roots and begin to grow as independent plants. Some are adapted for even wider dissemination. The spines which they bear are very sharp, stiff, and barbed. They penetrate the skins of passing animals and cling so tenaciously that the joints bearing them are readily detached from the parent plant and may be carried a considerable distance before being released from their carrier. Once lodged in proper soil under favorable climatic conditions, they soon become new individual plants. In many of the opuntias the fruits are proliferous. They may be removed and treated as cuttings and will readily produce new plants. Many of the smaller forms, such as Echinocactus, Echinocereus, and Mammillaria, produce branches (pl. 2, A and B), which are readily detachable and are easily rooted as cuttings. Some species of Mammillaria, as well as Opuntia, have side shoots or branches which are so lightly attached that they break off by a slight touch. Such plants depend almost entirely on vegetative propagation, and some of them rarely produce flowers and fruit.

GRAFTING

Grafting is easily accomplished throughout this whole group of plants. The possibilities of uniting both species and genera seem to be unlimited. For a long time it has been a practice to graft Epiphyllum on Pereskia, or some upright, stiff-stemmed Cereus, in order to produce a more decorative bushy plant. The rat-tail cactus (*Aporocactus* (*Cereus*) *flagelliformis*) is frequently treated in the same manner. Aside from its ornamental possibilities, grafting may be resorted to profitably as a means of propagation. It not infrequently happens that a plant becomes decayed at its base, and when all evidence of decay or disease has been removed there will be so little healthy tissue left that it is next to impossible to get it to grow as a cutting. Such a piece may be grafted on a healthy stock and the plant be preserved if the growing tip is intact. A cleft graft or a saddle graft is more desirable where either of these can be employed, since they require less work in preparation and give a good large surface for the union of the tissues. The mucilaginous sap that exudes from the cut surface of a cactus plant causes the stock and scion to slip apart very easily, and the parts become disarranged unless proper precaution is used to prevent it. For this purpose the needlelike spines of Pereskia or Opuntia may be used. The two parts are pressed firmly together into the desired position, and then a spine is thrust through the united portions, securely pinning them in that position. No wax is required, but it is best to closely wrap the graft with raffia to exclude the air. The grafted plants are then placed in a warm, moderately moist place until the tissues have become thoroughly knitted together. They should not be placed where they might be subject to drying, for under such con-

ditions the cut surface will be the first to dry, and consequently a perfect union will be prevented.

With small globose or thick plants, such as Mammillaria (pl. 3, A, B, C, and D), Echinocactus, and Echinocereus, a different method is preferable. The head of the plant is cut away with a perfectly smooth transverse cut (pl. 2, C). A stock is selected which has about the same diameter as the scion, and it is also given a smooth transverse cut. The two flat surfaces are then pressed firmly together and held in place by tying them together with a cotton or other soft cord. It is essential that clean instruments be used to prevent the inoculation of the plant with germs of decay. A number of the upright-growing species of Cereus have been successfully used for stocks, and there seems to be no limit to the number of species that may be used. It has been found, however, that some are better than others for the purpose. When it is desired to have the scion a foot or more high, good stocks may be obtained from *Lemaireocereus* (*Cereus*) *stellatus*, *Nyctocereus* (*Cereus*) *serpentinus*, and other species of similar habits of growth. (Pl. 4, A, B, and C.) These stocks are preferable for use in grafting *Aporocactus* (*Cereus*) *flagelliformis* and species of Epiphyllum (pl. 5, D) and Rhipsalis, which normally grow in a pendent position. Where only short stocks are desired, the above may be used, and also *Selenicereus pteranthus* (*Cereus nycticallus*), *Harrisia* (*Cereus*) *tortuosa*, *H.* (*C.*) *bonplandi*, *Selenicereus* (*Cereus*) *macdonaldiae*, and *S.* (*C.*) *grandiflorus*. These latter plants are weak stemmed when allowed to grow tall; hence, they can not be used for high grafts unless supported by a stake of some kind. All these species are readily grown from cuttings, which should be somewhat longer than the stock is to be. When the cutting is thoroughly rooted it should be potted and kept in good growing condition until a new root system has formed. It will then be ready to receive the scion after having been cut back to the desired height.

CULTURE

Cacti are native from southern Canada to far down in South America. Between these extreme points there is scarcely any combination of atmospheric and soil conditions that does not support one or more species of the family. They are found near the seashore in the Tropics, as well as high up on the mountains where in winter they are subjected to very cold weather. They are most abundant, however, in the high, semiarid table-lands. With these facts in mind, it is clear that when collected they can not all be treated alike, but must be grouped according to the conditions under which the individuals grow in their native haunts, and each group must receive a different treatment to accord therewith.

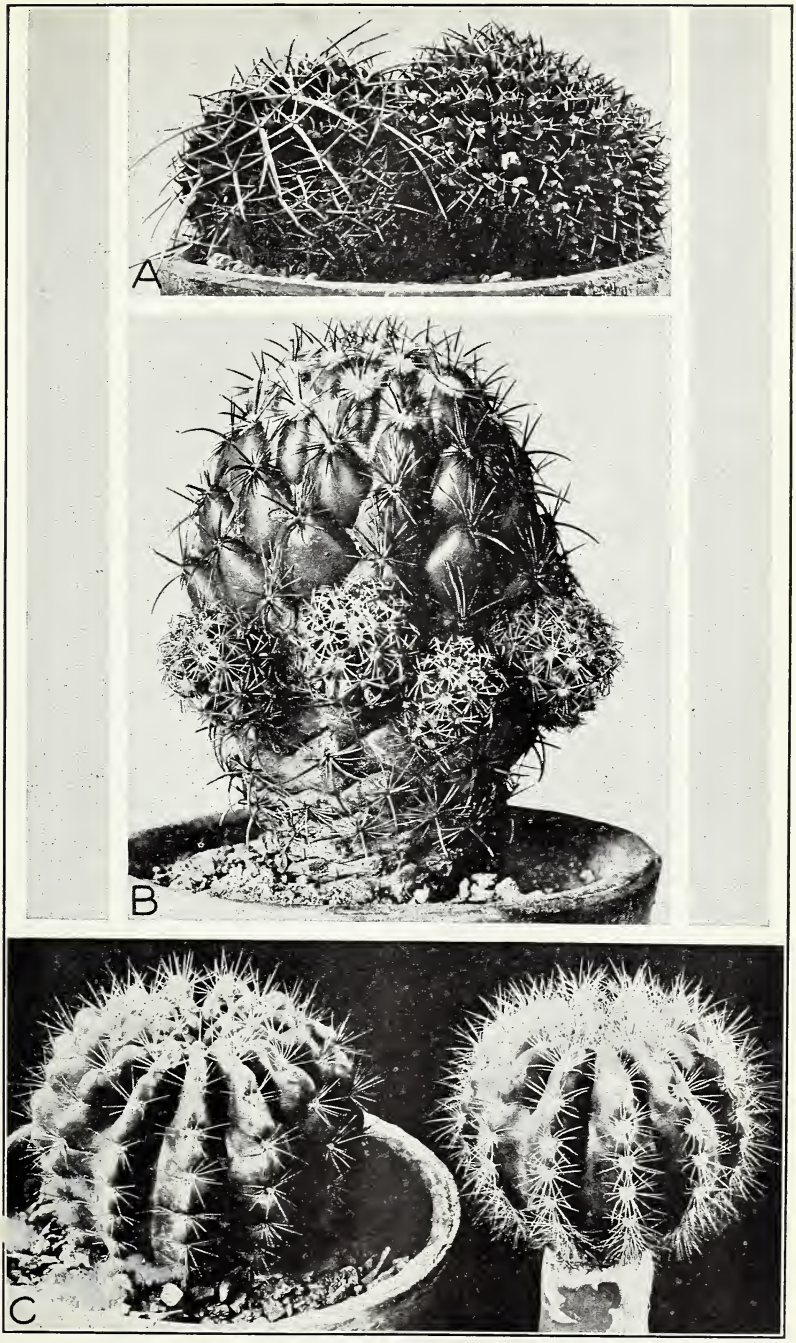
Epiphyllum, Rhipsalis, a few species of Phyllocactus, and some species of Cereus and related genera are epiphytic in their tropical homes and should be given like treatment in conservatories. They should be grown under practically the same warm, moist atmospheric conditions as are tropical orchids, which may be grown in baskets of peat and moss, or be trained on blocks or stumps, or on walls, wherever the roots have opportunity to penetrate a moisture-laden medium. Most species of Phyllocactus and the climbing species of

Cereus should be grown in orchidlike conditions of temperature and humidity, but in very loose, moderately rich soil. For this purpose a mixture of loam, sand, and an abundance of thoroughly decomposed leaf mold makes an excellent soil. By far the greater number of species of cacti are terrestrial in their habits and are indigenous to warm, semiarid regions. The annual rainfall in these regions is very slight and continues for only a brief period. It is difficult to reproduce such conditions in our northern climate, and it is found that cacti can best be grown here by minimizing the action of our abundant rains by having the plants placed in a thoroughly well-drained situation. It is equally difficult to reproduce the conditions in our conservatories, where they are heated artificially, because of the drying effect of the heat. This condition may be largely counteracted by a judicious watering of the soil about the plants. For this group of plants it is not necessary that the soil be rich, but it is essential that it be very open and thoroughly drained.

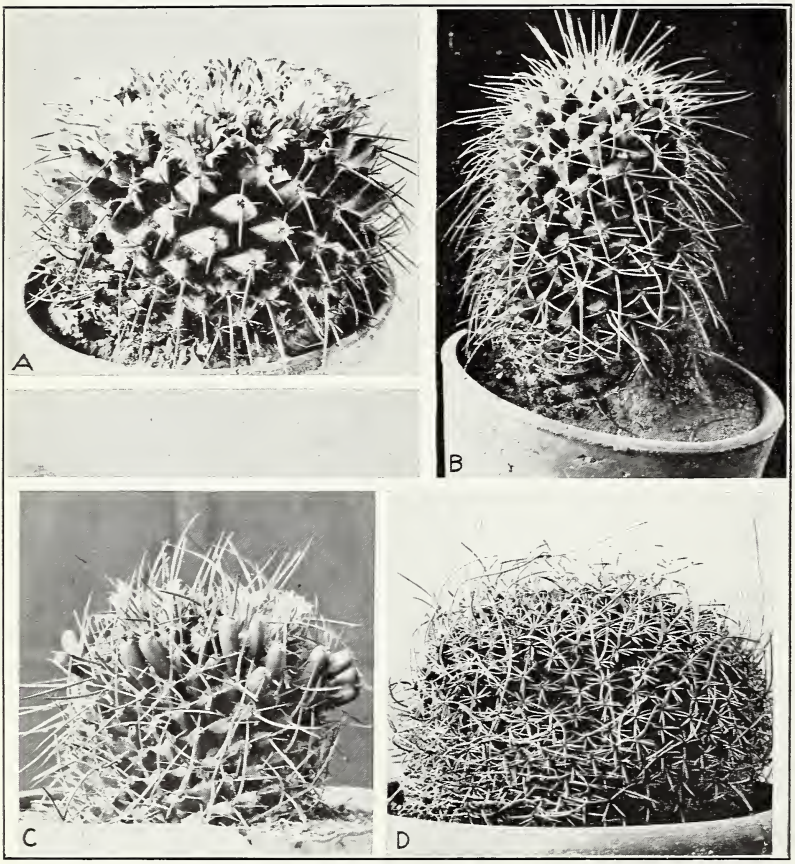
In repotting older plants it is best to disturb the roots as little as possible. Enlarge the drain opening in the bottom of the pot and place over it bits of broken pots or other coarse material to a depth of not less than 1 inch, to insure perfect, uniform drainage. Over the coarse material put a layer of soil. Remove the plant to be repotted by inverting the pot and gently tapping its rim on the edge of a bench or some such solid structure. The whole body of dirt will come out in a lump. Remove any bits of broken pots that may be attached to the bottom, but leave the soil in place about the roots. The surface soil should be removed if it shows any evidence of containing algae or fungous growths. Place this ball of dirt and roots in the next pot and pack fresh soil about it, leaving sufficient space at the top to receive water. In conservatories pots are apt to become coated with green algae, and old pots especially so, because the spores of the algae are likely to remain in the pores of a pot from its previous use. Old pots should be thoroughly sterilized, as heretofore explained for the germination pots. After the plant is potted, the surface of the soil should be covered with fine gravel to a depth of at least half an inch.

The soil about the plants should never be allowed to become absolutely dry for any great length of time or the roots will be seriously injured; on the other hand, it must not be kept saturated, but should be kept slightly moist at all times. Any superfluous water standing about the base of the plant or in the soil about its roots is a serious menace, since it acts as a medium through which germs of rot enter the plant and soon destroy it. Cactus plants contain so much liquid that decay works very rapidly through them. When decay once starts it is difficult to save the plant, hence the urgent necessity for having thorough drainage below the plant and a thoroughly drainable soil. Failures in the growing of cacti are undoubtedly due more to the neglect of this precaution than to all other causes combined.

Cacti do not need to be pruned beyond the removal of dead portions and to keep the plants in shape within the space allotted to them. Pruning may be done at any time, but preferably when the atmosphere is dry, so that the cut surface may dry and heal quickly.



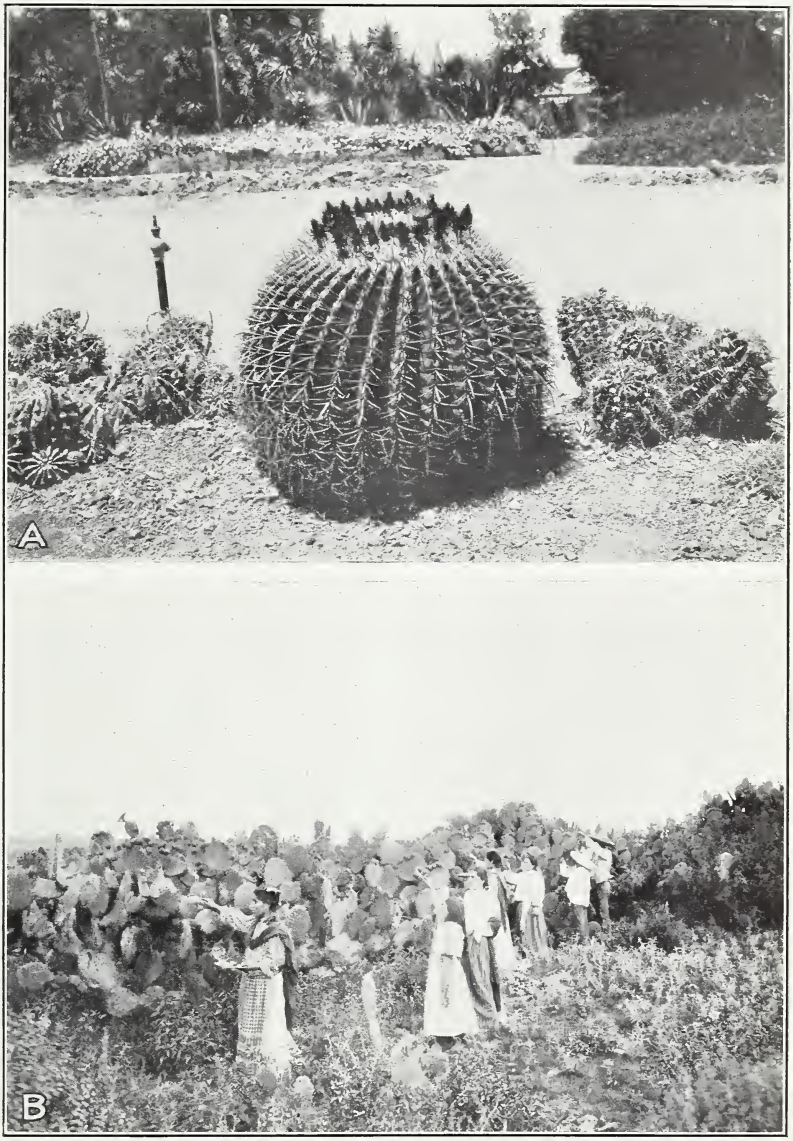
A.—*Neomammillaria (Mammillaria) pyrrhocephala.* Missouri Botanical Garden, 1910. B.—*Coryphantha (Mammillaria) cornifera.* Missouri Botanical Garden, 1899. C.—*Echinopsis calochlora,* showing the development of more spines in the grafted plant than in its parent. The grafted plant is an offset from the other. Missouri Botanical Garden, 1907



A.—*Neomammillaria magnimamma* (*Mammillaria centricirrha*). B.—*Neomammillaria compressa* (*Mammillaria cirrhifera*). C.—*Neomammillaria* (*Mammillaria*) *carnea*. D.—*Neomammillaria mystax* (*Mammillaria mutabilis*)

A.—*Lemaireocereus* (*Cereus*) *stellatus*. Tomellin, Mexico, 1909. B.—*Lemaireocereus griseus* (*Cereus eburneus*). Tomellin, Mexico, 1910. C.—*Pachycereus* (*Cereus*) *marginatus*. Encarnacion, Jalisco, Mexico, 1905

A.—Flower of *Echinocereus enneacanthus*. Missouri Botanical Garden, 1901. B.—*Wilcoxia poselgeri* (*Cereus tuberosus*). Missouri Botanical Garden, 1899. C.—*Echinopsis turbinata* (*gemmata*). Missouri Botanical Garden, 1908. D.—*Zygocactus* (*Epiphyllum*) *truncatus*



A.—*Echinocactus grusoni* with *Echinopsis turbinata* (*gemmata*) on either side. A. S. White Park, Riverside, Calif., 1904. B.—Gathering the pulp of tuna cardona fruits (*Opuntia streptacantha*). State of Zacatecas, Mexico, 1905

A.—One way of extracting the edible pulp from the fruits of tuna cardona (*Opuntia streptacantha*). State of Zacatecas, Mexico, 1905. B.—A young prickly pear orchard in its second year's growth. San Luis Potosi, Mexico, 1909

In conservatories during the colder season, in order that the air may be sufficiently dry, a temperature ranging from 60° to 70° F. should be maintained. A temperature lower than 60° for any considerable length of time would hold the moisture about the plants too long and invite decay. During the warmer season, if the plants are kept in the house, it is necessary that it be kept fully ventilated. The aim is to have at all times a dry atmosphere and a moderately moist, well-drained soil. If the plants are placed in open ground during the summer months and their pots plunged in the beds, these beds likewise must be thoroughly drained. In placing a collection out of doors as a permanent planting, a situation should be selected if possible where the ground slopes sufficiently to insure perfect drainage. If natural drainage is impossible, a system of draintiles should be placed throughout the area to be planted, and the soil above the tiles should be made loose and porous by the abundant addition of gravel and sand. Out-of-door planting is preferably done during the dry season, so that the cut surfaces or any injured portions of the plants may dry quickly, heal over, and be less easily infected with rot.

DISEASES

The one disease from which cacti suffer more than any other is rot. The plant body is so saturated with water that it forms an excellent medium for the growth of rot-inducing organisms. This malady is likely to attack the plant at any point. Any cut or bruised place presents the most favorable point for infection, from which rot spreads rapidly and destroys the plant. Water dripping on a plant for even a short time may induce infection. By far the greater number of plants receive the infection through their bases or roots, whence it works upward through the center. By the time it has reached the surface the plants are usually too far gone to be saved. If the diseased condition is detected before it has reached the crowns of the plants they may be saved by cutting away all the diseased portions and then grafting the crowns on some healthy stock. Otherwise it is best to remove the plants at once and burn them. The soil in which they were potted and also the pots, if they are to be used again, should be sterilized, so that other plants may not be infected from them.

Another disease, more common to species of Mammillaria and to a less extent found on Echinocactus and Cereus, makes its first appearance as a small light-orange colored spot on any portion of the plant surface, usually starting at a pulvinus, which seems to be the point at which the infecting germ enters. This spot steadily grows until the plant is totally destroyed. The disease travels inward, toward the center of the plant, following fibrovascular bundles. The colored tissue readily separates from the healthier portion of the plant and is easily removed, but this merely checks its ravages for a time. The disease penetrates every portion of the plant and in time will make itself manifest again in other orange-colored spots on the surface. It is a contagious disease, and the only hope for saving a collection

of plants is to destroy all the infected individuals, preferably by burning them. Many suggested remedies for this disease have been applied, but without success.

INSECT PESTS

The Bureau of Entomology of this department has investigated cactus insects extensively. The results of this work appear in a bulletin (*8*).

Cactus fanciers in the Southwest, particularly in California, should be careful not to introduce the native cottony cochineal (*Dactylopius tomentosus*) into their plantings. This insect is particularly injurious when introduced without its parasites, which has been done in at least one notable instance in California. When this insect is brought into a planting it multiplies rapidly during the long, hot, dry summers and is very destructive to a large number of species of prickly pears. It does not attack them all, however.

In the plantation on the United States Plant Introduction Garden at Chico, Calif., it was introduced on New Mexican species of Opuntia and spread rapidly to species from Texas and Arizona, and also certain ones from Mexico. It has not attacked the cylindrical species, the spineless forms of the Indian-fig group, the mansa forms (large cultivated Mexican species), or the large tree forms generally, with the exception of *Opuntia monacantha*, of South American origin, which proved to be particularly susceptible. This species was completely killed in a short while. In Australia the introduction of *Dactylopius indicus* from Ceylon, it is said, has cleaned out *O. monacantha* in sections where it was once a pest.

While *Dactylopius tomentosus* did not originally attack the large tree forms of Mexico at all, there are indications that lack of proper host plants compels it to change its food habits. It is now attacking nopal cardon (*Opuntia streptacantha*), which for 10 years was entirely immune in the Chico plantation.

ECONOMIC VALUE

MEDICINES

To a limited extent *Selenicereus* (*Cereus*) *grandiflorus* and *S. pteranthus* (*C. nycticallus*) have been used in the preparation of certain compounds. Other cacti are known to contain characteristic alkaloids which from their peculiar action on the human system may yet prove of value in treating special disorders. Most notable of these forms is the so-called pellote (pronounced peh-yo′-te) or mescal button, also known as the dumpling cactus (*Lophophora williamsii* and *L. lewinii*). Since remote times the aborigines of North America have used this plant in certain of their religious rites. When the plants are eaten raw, dried, or fresh, with water, the optic nerve is so affected that by closing the eyes the user is made to see visions illuminated in the brightest of colors. An alkaloid of this plant has been separated from it and found to contain the same properties. It is not impossible that in time it may be found of value in the treatment of certain ocular disorders. However, no member of the family seems as yet to have yielded a drug that has been used to any considerable extent as a medicine.

It is maintained by reputable physicians that the poorer classes of Mexico, while subsisting for some weeks on a diet largely made up of the tuna (fruit of the prickly pear) receive in addition to its food principles a valuable conditioning of the digestive system. After living the greater part of the year on such concentrated foods as tortillas, frijoles, black coffee, and little meat they receive great benefit from the diet of tunas, including always the large, angular, and bulky seeds which seem to exercise a beneficial effect on their digestive systems.

The diuretic influence of the fruit was early recognized, especially by Rafinesque (*18*). Whether there is a medicinal principle further than one of coloration has not been seriously investigated so far as the writers are aware.

The tender, succulent joints are split in two or macerated and then heated for use as poultices. They are admirably adapted for this purpose on account of the heat-holding quality of the mucilaginous mass.

GARDEN VEGETABLE

Among the poorer classes of Mexico the tender young shoots of cacti, especially the prickly pear, are made into a sort of salad and eaten raw, or they are cooked in various ways.

A sharp knife is run parallel to the sides of the joint, taking off the tubercles and spines. The young growth is then cut into strips or cubes, boiled in several changes of water to remove the mucilage, and then seasoned to taste. The material is also fried in batter in much the same way as eggplant.

CACTUS CANDY

For the manufacture of cactus candy the barrel cactus or Visnaga (*Ferocactus wislizeni*) and related species (pl. 6, A) are mostly employed, on account of the large bulk of soft tissue which the forms contain.

The exterior of the plant, together with the woody ribs, is all cut off. The soft, pulpy interior is then cut into strips or cubes, boiled in several changes of water to remove the mucilage, and then processed in cane sugar, flavoring, and coloring materials. The cactus, therefore, is mainly a matrix and furnishes the touch and possibly a little flavor to the finished product.

FRUITS

The fruits of a great many species of cacti are very agreeable to the taste, as well as refreshing and nourishing. This is especially true of those of many species of Opuntia known as tunas. (Pls. 6, B; 7, A and B; and 8, A.) In certain parts of Mexico the tuna forms a considerable part of the diet of the poorer natives. In many places it is grown for the market and finds ready sale among all classes. The inner pulp, containing the seeds, not only possesses a pleasant flavor but it also creates the impression of being cool even in the hottest weather. Forms of tuna have as wide a range in color, flavor, and size as many of our northern fruits.

These opuntias are grown in small orchards (pl. 7, B) with a minimum of attention and add materially to the food supply. In the

general region of San Luis Potosi and Aguas Calientes the most important fruit of this class is tuna cardona (*Opuntia streptacantha*) (pl. 7, A, and pl. 6, B) from which tons of preserved products are prepared each year. It is a native wild species with comparatively small fruit, but its expressed juice contains a large proportion of solids in suspension rather than in solution like the mansas (pl. 7, B) or cultivated forms.

In the manufacture of the tuna products only the pulp of the fruit is used. Workmen use a sharp knife in the right hand to make a cut across the top and down one side of the fruit. (Pl. 7, A.) Then with the thumb and index finger of the left hand they push apart the rind of the fruit and pick out the pulp ball, placing it usually in earthenware ollas (oyas) strapped on their backs.

The seed is removed in crude homemade colanders. This expressed juice is evaporated to different degrees of consistency and stirred, puddled, and kneaded in various degrees into miel, melcocha, and queso, which keep indefinitely. Queso, as the name implies, is of the consistency of cheese and keeps almost indefinitely without change except for hardening. The others crystallize in a few months but are still edible.

Often the tunas, especially the mansas (cultivated forms), are peeled with a sharp knife, leaving the greater part of the rind on the pulp. They are then dried in the sun much as figs are dried.

A beverage called "colonche" is also prepared from the tuna fruits. The expressed juices are strained, evaporated to the proper degree, and then allowed to ferment or not, as the user prefers. It is employed mostly as a fresh juice for about 20 days, which is about as long as it can be kept.

Indeed, the varieties of nopales (Opuntia) in the small orchard (pl. 7, B) around the dwellings of the poorer classes rival in their diversity the varieties of apples in the northern orchards. This is not all. These people have names for all of them and in their crude way have selected the best forms for untold generations. Nearly every orchard will contain some "lisos" (pls. 9, A, and 8, B) or spineless forms, which are the result of local selection, and they differ widely in different sections.

It will be more fully appreciated how diverse and important the tunas are when it is realized that many natives live for a month or two on a diet largely of these fruits; that some of the larger haciendas receive several thousand pesos annually for their crops of the native fruit (pl. 7, A), which require no care or expense to produce; and that tunas exist which mature early, and others which do not mature before winter. Some are suitable for one purpose and some for another, some are eaten fresh and others only after being cooked, while still others are suitable only for the manufacture of pickles.

While the tuna is by far the most important of the cactus fruits, there is an exceedingly varied assemblage of other fruits of these spiny inhabitants of the deserts that are consumed in the home and offered for sale in the markets. They are known by various names more or less constant in circumscribed regions.

In southern Texas considerable use is made of the Mexican strawberry (*Echinocereus enneacanthus*) (pls. 9, B, and 5, A) both fresh and preserved; the fruit of *Wilcoxia poselgeri* (*Cereus tuberosus*),

although never abundant, is delicious (pl. 5, B); south of the Tropic of Cancer on the highlands of Mexico garambullos (*Myrtillocactus geometrizans*; pl. 10, A) furnishes a sweet morsel resembling a gooseberry; north of Oaxaca the fruit of *Lemaireocereus weberi* (pl. 10, B) is considerably used under the name "cardon," similar in name to the tuna of *Opuntia streptacantha* farther north; chilitos are the red, smooth fruits of Mammillaria and related genera (pl. 3, A, B, C, and D; and pl. 11, A, B, C, and D) which are sprightly in flavor and often very palatable, while the fruit of *O. imbricata*, called tuna "juell" (pronounced whay), which is 3 per cent acid, has been used as a mordant in setting cochineal dye.

WOOD

All cactus plants are composed for the most part of soft, water-laden tissue, but the axis of the plant is composed of a woody core, which in some species makes a considerable development, especially in Opuntia and the large species of Cereus and their allies. This woody portion is always more or less porous and usually of an open, lacelike structure, so that it is of little value as compared to other woods. Nevertheless, it is used to some extent in the manufacture of ornaments and rustic work, but more for its curious structure than for any real value the wood may possess. Some of the cylindrical forms of Opuntia yield rather grotesque and ornamental walking canes, as do also a few of the slender-growing columnar species of Cereus. These forms also furnish wood for rustic picture frames, ornamental pincushions, trays, inkwell stands, and the like. To a limited extent the wood of the taller growing species forms material in the shape of poles for the construction of fences and temporary huts.

HEDGES

Because of their animal-resisting armor of spines, combined with their habit of growth, certain species of cacti are naturally adapted for use as efficient hedge plants wherever they grow in the open throughout the year. The one species most commonly used in Mexico for this purpose is the organo (*Pachycereus* (*Cereus*) *marginatus*) (pl. 4, C), so called because of its fancied resemblance to the pipe of an organ. It branches freely from the base near the surface of the ground, and these branches immediately assume an upright habit of growth. Growing closely together they soon produce an impenetrable barrier. Its habits of growth recommend it, since there are scarcely any branches above the base and these never spread and cover any great area, thus making a compact, dense, and comparatively narrow hedge. *Lemaireocereus* (*Cereus*) *stellatus* (pl. 4, A) and *L.* (*C.*) *weberi* (pl. 10, B) are also used in the regions where they are abundant as native plants, but they have the disadvantage of making a thicker and more open hedge and consequently cover more ground. Where narrowness of the hedge is of minor importance, many of the taller growing species of Opuntia make an equally serviceable barrier and are at all times decorative, especially when bearing an abundance of flowers and fruits.

Similar use is made of the leafy cacti (Pereskia) in some tropical countries. The Barbados gooseberry is commonly put to this use.

DECORATIVE VALUE

It is not intended to convey the idea that cacti, as a whole, can hope to rival many other groups of plants in gorgeous display, but they are unique, peculiar, and particularly fitting in some regious and can be made very attractive in many settings. (Pl. 12, A and B.) For the most part they lack the foliage that lends so much to the value of other plants, and in many instances the flowers, when present, are either too small, too few (pls. 13, A, B, and C; and 5, C) or too short lived to be considered of great worth, but they have many attractions of their own. In some of the climbing species of Cereus, Phyllocactus, and related genera the flowers attain a very considerable size, and their waxlike texture and pure whiteness or delicate tints of red, pink, or cream present combinations that call forth exclamations of wonder and pleasant surprise. Many forms bloom at night, and their flowers are always white and to a slight degree pleasantly fragrant. The flowers are usually produced in periods, each period lasting from one to three or four days. At such a period the plants, if mature and vigorous, will bear a large number of flower buds, which open in the evening after sunset and close with the approach of strong morning light, never again to open. The following night other buds will bloom, and so on until in a few days all will have passed the blooming period, which, after an interval of time, will recur. In our northern conservatories there are usually three or four such periods during the summer season, averaging about four or five weeks apart. On these occasions the display of large white flowers in abundance in the moonlight is a wonderful sight. Most of the species of Echinocereus produce comparatively large showy flowers in a crown about the ends of the branches. They are very attractive in their highly colored (yellow, orange, red, and purple) waxy flowers, but they do not respond so readily to cultivation as many others, especially in greenhouses. Some species of Echinopsis (pl. 5, C) also produce flowers in abundance for a period of a few days. These are trumpet shaped, upright, about 8 inches long, forming a crown about the top of the plant. They range in color from pure white to pale yellow or rosy pink.

The opuntias are commonly large and rampant in growth. Consequently, the number of individuals used is smaller, as a rule, not because they are less attractive, but because they occupy so much space. However, many of these species are small and well adapted to be incorporated in the collection held in cramped quarters either outside or in the living room.

The smaller of the opuntias may be very properly illustrated by the *Opuntia basilaris* group, which is one of the most common in collections. It inhabits naturally that most interesting region extending from the western slope of the San Francisco Mountains across the southern Sierras into the interior valleys of California. In the region of the pass south of the San Bernardino Mountains and the valleys beyond, the *ramosa* variety predominates. Upon the western slopes in the region of Cajon Pass, north of these mountains, *O. brachyclada* (pl. 1) and *O. humistrata* are found, while in the Tehachapi and its environs occur *O. treleasei* and its variety *kernii*, the latter being very spiny and unique for the group.

The species of the group are very floriferous, the prevailing color being a deep rose purple, but there are white-flowered forms in most of the species and varieties. The plants are all low but erect, spreading, and mostly one to three joints high except *Opuntia humistrata*, which is prostrate. The whole group varies greatly in coloration of plant body, as do many species of cacti. Some are bright to glaucous green, others bear a reddish cast, while the young growth as well as the old in cold weather are copperized, giving very pleasing effects. These facts, coupled with their wonderful symmetry and compact growth, make the group very advantageous for some settings, and they are greatly admired and sought after.

The chief attractiveness and beauty in cacti as a group is the remarkable symmetry of growth in the individual plants. This is particularly well brought out in Plates 3, 9, and 11. The columnar, and most of the genera of smaller cylindrical or globular forms, have clean-cut, longitudinal, parallel angles, ribs, or wings, and located on them at regular intervals are the buds, or pulvini, which bear the spines and flowers and from which side branches may be developed. The coloring of the epidermis of the plant is frequently very attractive. While in most species this color is some shade of green, many specimens are coated over to a greater or lesser extent with white or bluish bloom. In some species the surface is dotted with very small bunches of velvety white hair, as in *Astrophytum* (*Echinocactus*) *myriostigma* (pl. 11, B), *A.* (*E.*) *ornatum*, and *A.* (*E.*) *capricornis*. Other species are mottled with purple, which in the young growths of *Echinocactus ingens* is arranged in transverse bands alternating with bright green. The coloring of the spines, too, is often exceedingly attractive, especially in the younger growths. It ranges from pure white to amber, yellow, red, and black. Frequently some of these colors are combined on one spine in either longitudinal stripes or transverse bands, and the perfectly uniform variegation is very striking. The form, structure, and arrangement of the spines are in most instances remarkable and show a wonderful adherence to a definite plan of symmetrical arrangement. In certain species some of the spines have a structure of soft and hard transverse layers from base to tip, giving an uneven though uniformly wavy surface much like that of a goat's horn. The larger number of spines are straight or only slightly curved; others have the end curved in the form of a fishhook. Nearly all of them are rather stiff, but some are soft and featherlike in structure and others are thin, flat, paperlike, and flexible. Again, in some species the spines are entirely absent.

Mammillaria (pl. 3, A, B, C, and D) and some groups of Echinocactus have all the variations of characters already described, but they differ materially in body structure. In them the ribs or angles have entirely disappeared and are represented by rows of tubercles or mammae, each bearing at its summit a cluster of spines. In this group the tubercles are not arranged in longitudinal rows, but are geometrically tessellated over the plant surface, so arranged as to form spirals running in both directions about the plant.

A remarkable and interesting feature is the regularity in number with which these spiral rows appear. As a rule, they fall into the numbers 5, 8, 13, 21, 34, 55, and possibly higher numbers. For

example, if it is found that there are 13 parallel rows of tubercles running obliquely around the plant in one direction, there will be either 8 or 21 such parallel rows running obliquely around it in the other direction. Whatever the number of rows counted in one direction, the number counted in the opposite direction will be the one either preceding or following it in the series. Exceptions to this rule are rare, and when one is noted the numbers are usually found to be the doubles of two adjacent numbers in the above series, as 10, 16, 26, 42, and so on. Another interesting fact is that each number in the series is the sum of the two immediately preceding it.

While symmetry is the greatest attraction in this group of plants, monstrosities are not infrequent in the family, usually assuming a cristate or cockscomb form of growth. (Pl. 14, A; and pl. 11. C.) These forms are so odd in appearance that they are always sought after, and it is common to find them represented in the collections of amateurs. Their very grotesqueness commends them to the consideration of collectors. They are found in all groups, but occur most frequently in the columnar species of many genera, particularly in Cereus and Opuntia and their allies. The forms are usually designated by the term "cristata" following the scientific name of the plant. They command a high price, usually twice as much as the normal forms or more. A rare and beautiful example of this kind of variation is shown in Plate 14, A.

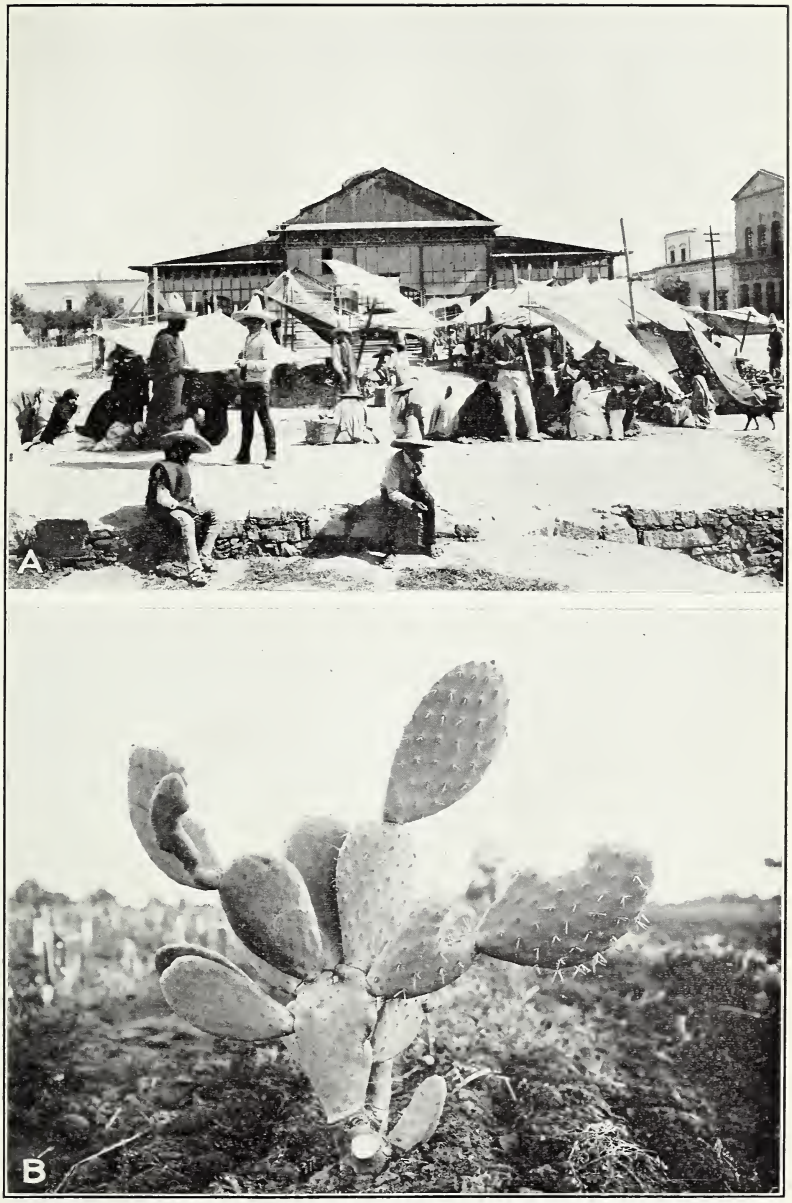
SINGLE-PLANT DISPLAYS

Each individual plant has an attractiveness of its own (see pls. 3, A; 9, B; and 10), whether it be the symmetrical order of its trunk, its color, its versicolored or versiform spines, or a combination of all these features, supplemented in its proper seasons by the production of flowers and fruits. Each normal, healthy plant is well worthy of consideration as an individual specimen. The adaptability of individuals is such as to commend them for situations where many other plants could not exist. They do not require frequent repotting and replenishing of soil, and subsist best on a periodical distribution of water, so that if necessarily neglected for a time they do not materially suffer. A single plant is well worth the little trouble required for its keeping. It occupies a very small amount of space in comparison to its weight, which is an advantage in many instances.

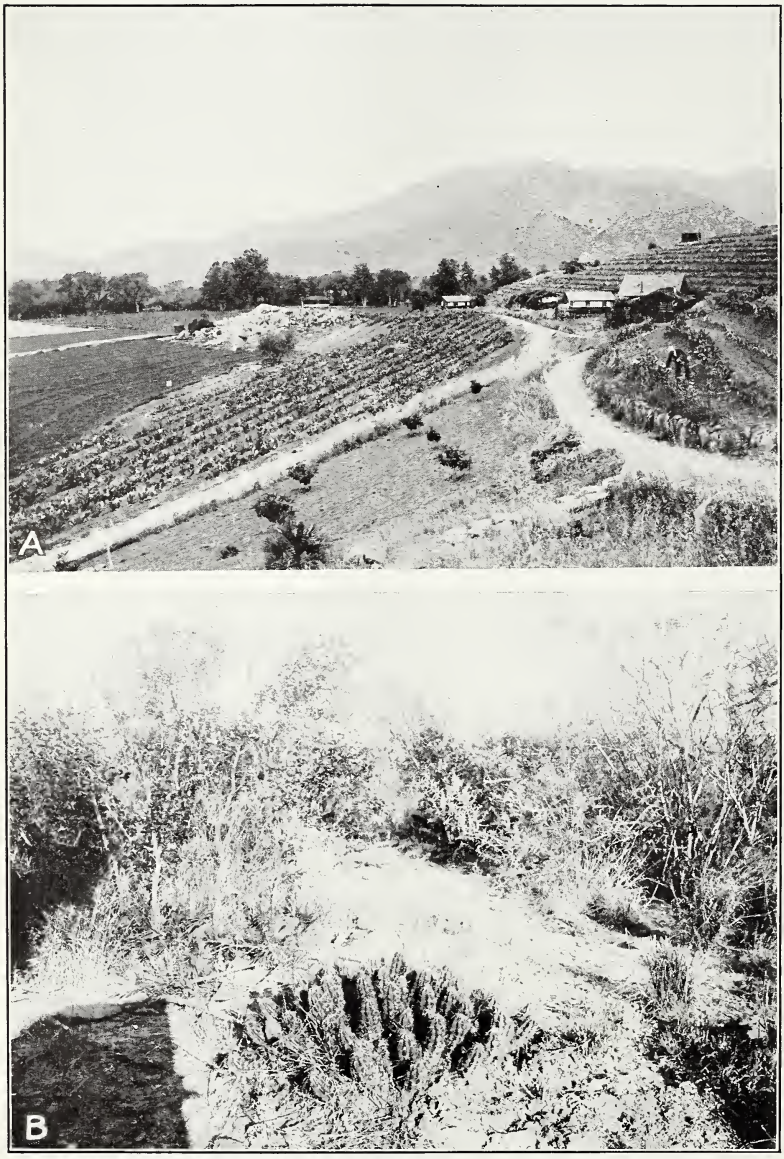
A pretty and interesting display may be had by arranging the plants in groups on benches, on window sills, or on bracket shelves on either side of a window. Pots of individual plants of various sizes lend themselves very readily to artistic arrangement. In any banking effect the larger and taller ones should be placed in the background and the rest graded down to the front according to the size of the plants. Should the plants be too uniform in size for such an arrangement, those in the background may be elevated on inverted pots or blocks of wood of suitable height.

GROUPINGS

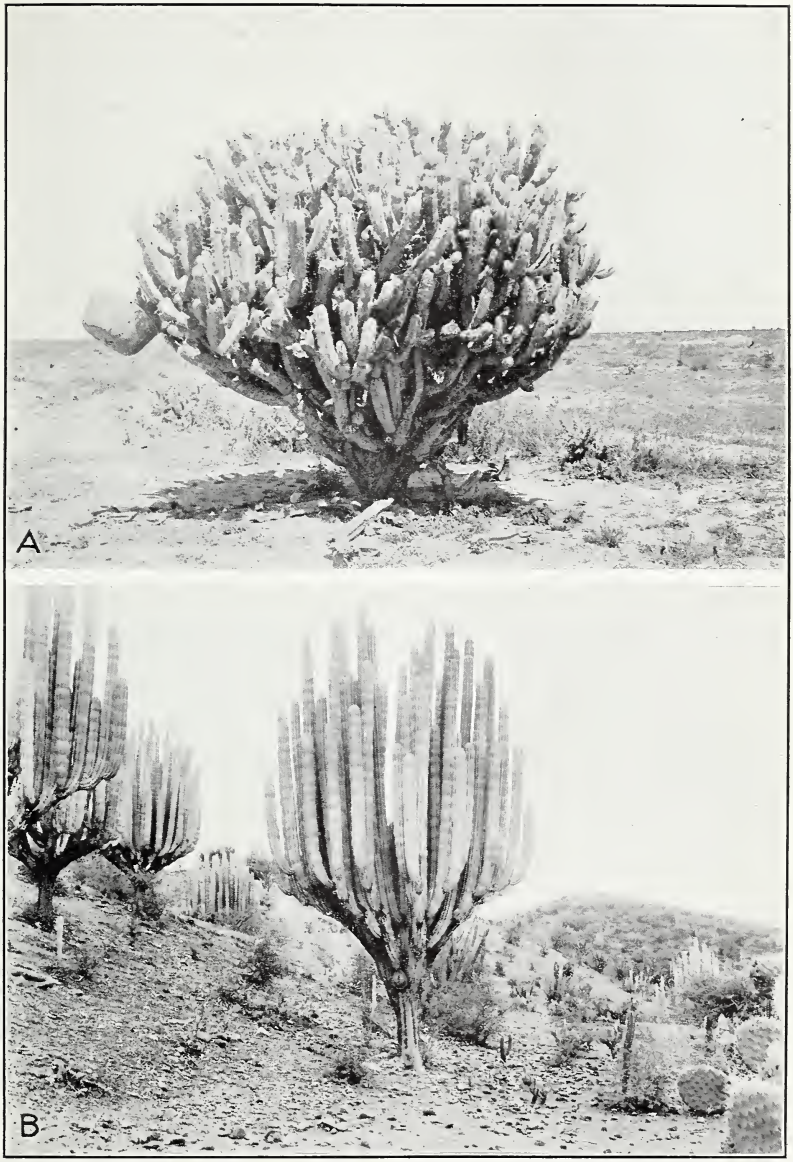
Pleasing effects may be obtained by placing a number of plants in one pot or small box. For this purpose it is necessary to choose small plants, preferably the low-growing globular or short, cylindrical forms of Mammillaria and Echinocactus. With a little care



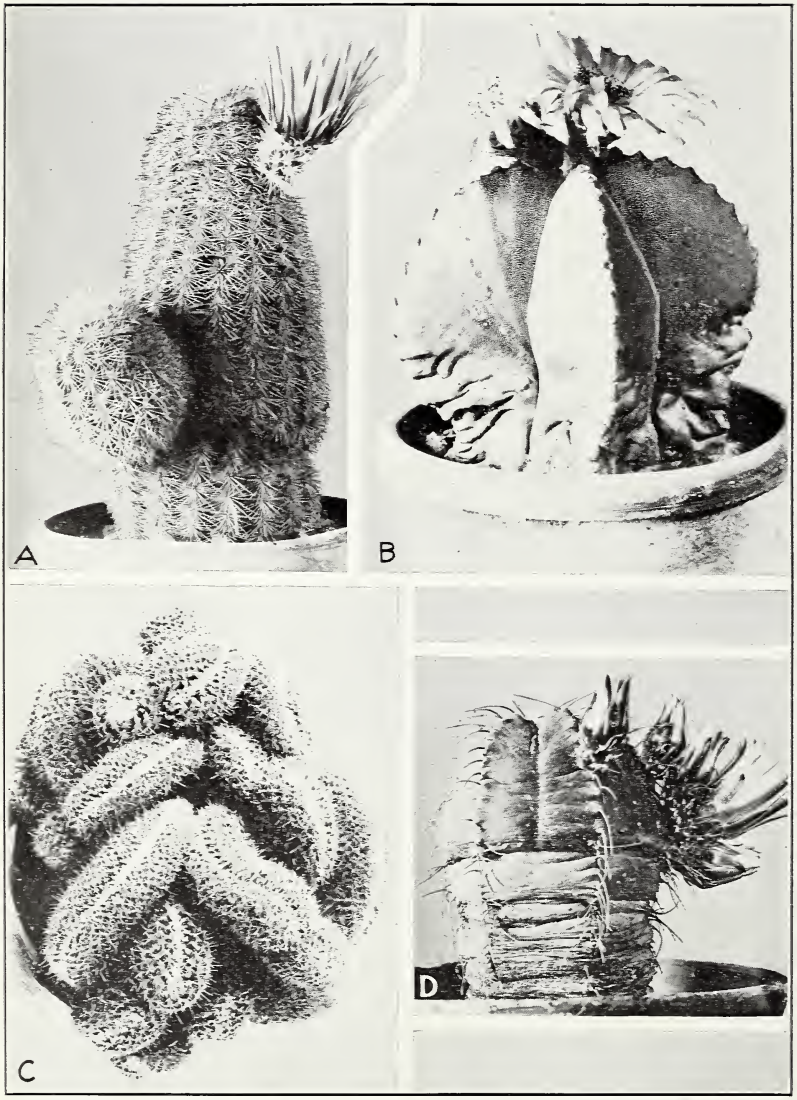
A.—A tuna market at San Luis Potosi, Mexico, 1905. B.—A bud variation in one of the spineless Sicilian varieties of Opuntia grown at the United States Plant Introduction Garden at Chico, Calif., 1911. The spiny portion bears a very suggestive resemblance to *Opuntia amyclaea*



A.—A spineless-cactus ranch in southern California, 1914. B.—*Echinocereus enneacanthus*

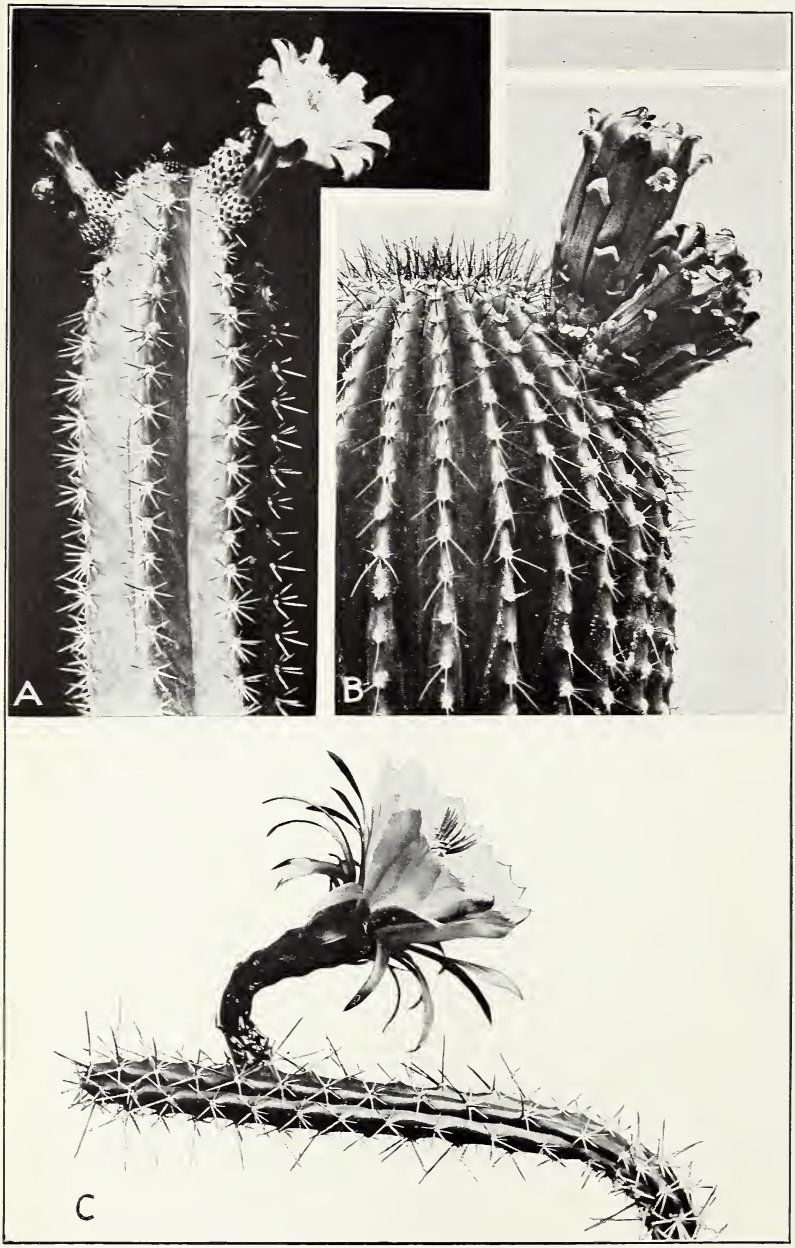


A.—*Myrtillocactus* (*Cereus*) *geometrizans*. Solidad, San Luis Potosi, Mexico, 1905. B.—*Lemaireocereus* (*Cereus*) *weberi*. Tomellin, Mexico, 1909



A.—*Echinocereus dasyacanthus*. Missouri Botanical Garden, 1914. B.—*Astrophytum* (*Echinocactus*) *myriostigma*. Missouri Botanical Garden, 1901. C.—*Neomammillaria geminispina* (*Mammillaria bicolor cristata*). Missouri Botanical Garden, 1904. D.—*Echinocactus knippelianus*. Missouri Botanical Garden, 1901

A.—*Opuntia bigelowi*. Near Owens, Ariz., 1912. Known locally as "ball cholla." B.—*Opuntia arbuscula*. Santa Cruz Valley, Ariz., 1906



A.—*Lemaireocereus griseus* (*Cereus eburneus*). Missouri Botanical Garden, 1905. B.—*Cephalocereus* (*Pilocereus*) *polylophus*. Missouri Botanical Garden, 1905. C.—*Harrisia* (*Cereus*) *tortuosa*. Missouri Botanical Garden, 1908

in the selection of perfectly symmetrical plants with well-developed spines and some taste in arrangement, a compact group may be built up which will make an excellent ornament for the table or window and can easily be moved to any place desired. In the diversity of designs which may be followed there is a wide range of possibilities, ornamental pots or boxes lending an artistic touch to the composition.

PLANTINGS IN OPEN GROUND

Cactus roots naturally penetrate deeply into the soil, and at the same time some of them spread widely from the plant stem. This tendency is necessarily limited in potted plants, and the plant does not receive the nourishment or water that it should have; hence it is always better to place them in the open ground if possible. In the Northern States it is necessary that the plants be protected from cold in winter. In such localities a room in a greenhouse may be set aside for this group of plants and beds made in the native earth to receive them. Here they may be placed close together, as they shade one another very little and do not have the abundant foliage of other plants. The roots may intermingle, but with no great detriment, since the main feeding roots penetrate deep down into the soil. Furthermore, cactus plants need comparatively little nourishment, and it would require a long time to exhaust the soil. An effective arrangement is to build up rocks and soil, leaving the surface more or less covered with rocks, making a genuine rockery. (Pl. 15, A.) This treatment lends a natural aspect to the surroundings and furthermore adds a greater degree of drainage, so necessary to cacti at all times.

Cacti may be used as good decorative plants in outdoor beds, planted either permanently (pl. 15, B) or temporarily (pl. 16, A and B). Where one has a number of individual potted plants that have to be housed for protection in the winter season it is always desirable that they be placed in the open during the summer months. They should be taken out as soon as all danger from frost is past and left till danger threatens in the fall. The beds should be either high or on a sloping surface, to insure thorough drainage about the plants. With such plants it is better to leave them potted and plunge the pots into the soil. Plants thus exposed to the sunshine and rain during the summer months will do far better than those kept indoors and given house treatment. A judicious arranging of the plants in such beds will have an attractive and pleasing effect. Where a large number of individuals of a few species are available, some artistic designs may be worked out in these summer beds, as shown in Plate 16.

In the warmer southern or southwestern portions of the United States a very large number of cacti will thrive out of doors the year round. In such localities the possibilities for bed planting have a much wider range. More area may be given to them there than would be possible in the conservatories of the North. They will require greater space, because plants that grow in the open thrive much better than potted ones and consequently branch and spread over a greater area. In such localities, with plenty of room, it is possible to produce decidedly realistic landscape effects. Especially is this true in parks (pl. 15, B), where the semiarid character of the

native home of the cacti may be reproduced with wonderful accuracy. Winding paths may be laid out through the tract and the borders planted in irregular groups, so that the effect will change as one passes along any of the walks.

Throughout the Southwest are to be found many very effective ornamental plantings of cacti, a very large proportion of which are various species of Opuntia of either the flat-jointed or cylindrical forms. These usually predominate, if not in variety certainly in quantity of material, mainly owing to their rapidity of growth and ease of propagation. A few collections are classic. Among the most noted should be mentioned the one in the A. S. White Park at Riverside, Calif. (pl. 15, B); the Huntington collection at San Gabriel, Calif.; the Letz collection at Hollywood, Calif.; and the small but effective university collection at Tucson, Ariz.; all of which are unique park examples. Whether for individual specimens or mass effect the plants possess an individual charm which might be described as grotesque by some, formal, stiff or delicate in coloration and blend of tone, depending on the temperament and point of view of the observer.

One of the most pleasing plantings of cacti which have come under the observation of the writers was the assemblage of Opuntia in the United States Plant Introduction Garden at Chico, Calif., about 1915. (Pl. 17, A and B.) Close to 3,500 numbers of this genus had been assembled here for study. They were planted from 4 to 9 feet apart, depending on the stature of the plants. The setting was made mainly for economic purposes, with no thought for ornamentation. Still the varied forms were exceedingly attractive throughout the year. A colored plate taken in the position of Plate 17, A, registered 11 distinct greens. This variation in color of plant body, coupled with the varicolored fruit and the copious inflorescence, all of intense interest and attractiveness, produced a very pleasing effect.

PECULIARITIES OF CACTI

To the lover of the unusual the cacti make a special appeal. Their differences from all other plants suffice to put them in a unique group. The Euphorbias of the African deserts simply simulate them in general aspect, but really are not like them.

Were one to define the group he could not do better than to say they are plants having specialized structures called pulvini, cushions, or areoles. (Fig. 1.) This definition sets them off from all other groups of plants. They are exceedingly diverse succulent plants whose vegetative portions are reduced to stems; whose leaves are rudimentary and function but a few days, if at all; whose buds are modified into pulvini or cushions, found in no other family. The cushions are usually not protuberances, like buds, but are actual depressions on the surface of the plant filled or more properly built up in a most complex way, often of three classes of spines, wool, glands, growing points, etc. The spines of one large genus (Opuntia) to which the prickly pears belong have retrorsely barbed spines and spicules. (Fig. 2.)

The cacti have lost their leaves and it may be said their branches as well, the plant body being columnar, globular, simple, or branched. Many of the species, especially of Opuntia, secrete nectar in their

flowers like other plants, it is true, but much more abundantly from the cushions on the stems. This secretion is so abundant that it dries into a globule of clear crystalline sugar on each pulvinus or cushion wherever there are no summer rains to wash it off.

The woody system is as variable as the plants themselves. It may be made up of a cylinder of woody strands, or a mesh, or lacework, with the modified buds at the intersections of the strands.

The fruits are of great interest. They are more clearly modified stems than those of almost any other plant. They bear rudimentary leaves and cushions of spines like the stems. They may be sessile on the plant or actually sunken into its tissues. They may mature

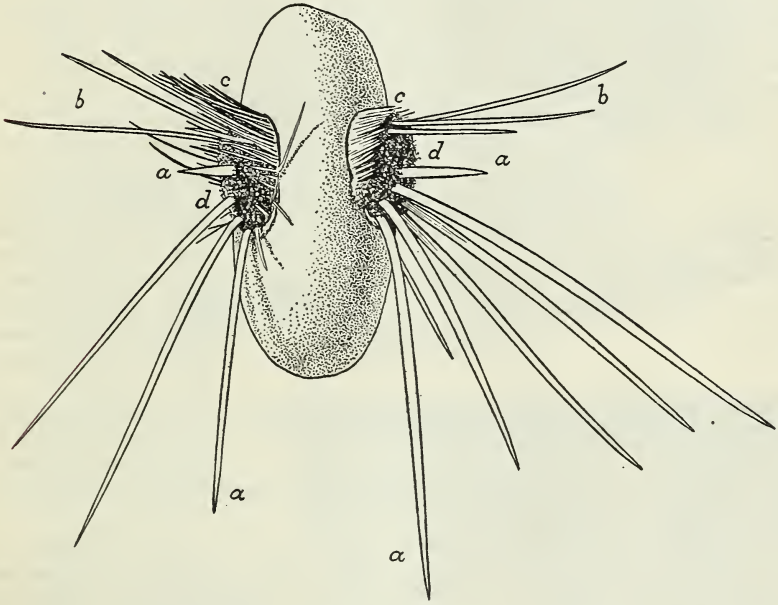


FIGURE 1.—Two contiguous cushions on the edge and side of a joint of prickly pear: *a*, Spines; *b*, bristles; *c*, spicules; *d*, wool. The bristles differ from both spines and spicules and are sometimes referred to as fugacious spines

at the end of the season, or they may remain attached to the plants indefinitely. They are usually single, but commonly proliferate into a large pendent cluster which remains perennially attached.

ATTRACTIVE INVESTIGATIONS WITH CACTUS SUBJECTS

Very little attention has been given to the breeding of cacti other than the genus Opuntia. Doubtless it is here that the quickest and most profitable results are to be obtained. But what can be accomplished in other groups has not been studied much.

The prickly pears are, however, very plastic, and variable hybrids are easily obtained. It has occurred to the writers that an investigator so situated that he can devote a liberal space to their culture might bring together some very instructive data from the study of a large number of crosses of these easily modified plants.

A study of vegetative reproduction in such forms as *Opuntia linguiformis* (pl. 18, A) would be exceedingly interesting. Certain strains of this species at least produce plants simulating the type of joint from which they are propagated. As an example, the plant illustrated in Plate 18, B, will reproduce itself vegetatively from the median strap-shaped joints, the lateral ovate ones producing a plant of entirely different appearance in that none of the long joints will be formed.

A study of the plants in the wild reveals some remarkable behavior in certain individuals. One prickly pear closely resembling *Opuntia bentoni* is recalled. It was found near San Antonio, Tex. The fruits habitually turned red in late summer like most species, but did not drop off as usual. Instead they turned green again during the winter and became incorporated as a permanent part of the plant, becoming vegetative, and giving rise to vegetative growth the next season. This growth was propagated for four or five years at Chico, Calif. The seed of these vegetatively turned fruits at 3 years of age showed unmistakable signs of erosion, indicating that an absorption by the plant of the once presumably fertile, sexually produced seed was taking place. The behavior of seed in fruits which have given rise to plants by vegetative means has received scant attention, but would make an interesting piece of investigation.

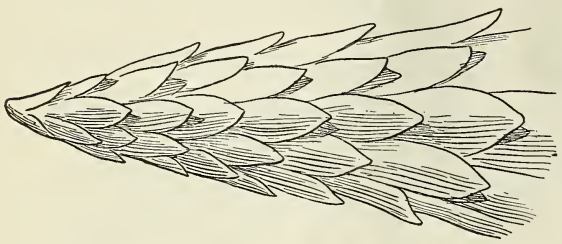


FIGURE 2.—Tip of a small spine of *Opuntia confusa*, highly magnified, showing the retrorse barbs, a characteristic of the genus Opuntia. × 350

A scientific study of fasciation (pl. 14, A) in these plants has received practically no attention. Since these aberrant forms are so much sought after by fanciers, investigations for the purpose of finding how to produce them might yield some economic results.

It would be very interesting to know just what takes place when the fly (*Asphondylia opuntiae*) deposits its eggs in opuntia fruits. By what adaptation do these fruits remain attached to the plants until May or June of the second year after the insect has emerged? In this case the fly causes the fruit to produce vegetative joints, but an aphis on another species causes fruits to proliferate into other fruits. (Pl. 18, B.)

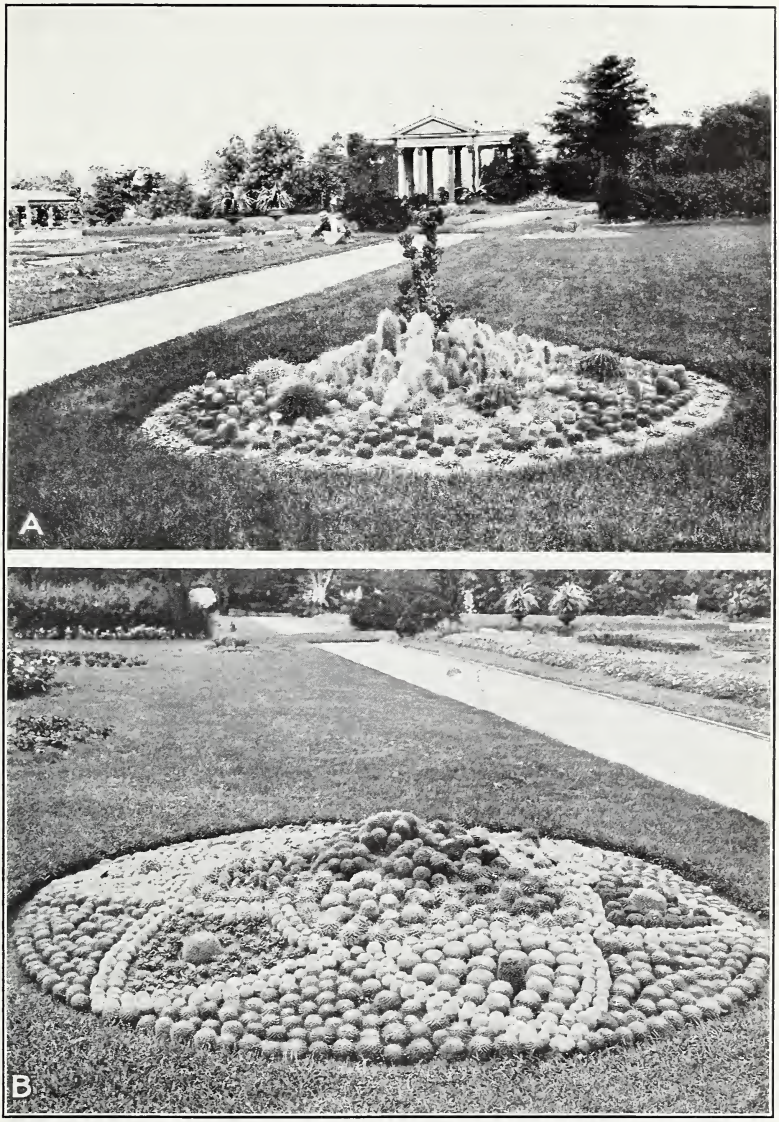
The origin and significance of the various structures in the pulvini or cushions (fig. 1) have never been worked out. Indeed, their morphological significance is not known. Some of them are not even named and have not received attention in systematic works.

A comparative study of spineless forms and the species from which they are derived would be profitable. Much light could be thrown on the subject by growing seedlings of the spineless forms.

An exhaustive study of the fruits of certain species which commonly are sunken into the body of the plant and their future be-

A.—*Carnegiea (Cereus) gigantea.* Santa Cruz Valley, Ariz., 1903. B.—*Pereskia bleo.* United States Plant Introduction Garden, Chico, Calif., 1918

A.—A limestone rockery planted to succulents, mostly cacti, in a public park at San Antonio, Tex., 1904. B.—A well-arranged cactus collection. A. S. White Park, Riverside, Calif., 1905



A.—A formal design in temporary bedding with cacti in which a banking effect is produced by the arrangement of the plants. Missouri Botanical Garden, 1905. B.—A formal design in bedding with cacti at the Missouri Botanical Garden in which the plants used are more uniform in size and the individuals of a species more numerous

A.—The prickly-pear plantation at the United States Plant Introduction Garden, Chico, Calif., 1915. A colored plate of this view registers 11 distinct greens. B.—Another view in the same plantation, showing some of the smaller species

A.—*Opuntia linguiformis*, which reproduces vegetatively two types of plants, depending on whether axial or lateral joints are used for propagation. B.—Proliferation of fruits in *Opuntia puberula* caused by aphids. In other species insects cause the fruits to proliferate not into fruits but into vegetative structures

A.—*Opuntia brasiliensis* grown in tubs out of doors in summer and inside in winter. This species is one of the most satisfactory for living-room culture. San Antonio, Tex., 1907. B.—*Opuntia basilaris*. Hackberry, Ariz., 1904. This represents one of the most common groups in collections. The flowers are very attractive

havior might throw further light on the relationship of stem and fruit.

Of what advantage is the tuberous root, especially to certain species of Opuntia? Tuberous and fibrous-rooted forms grow under identical conditions. A comparison of the development of these structures in seedlings and in vegetatively produced plants would be an interesting study.

Why do fruits of the proliferous-fruited species (Cylindropuntia) each succeeding year bud forth into new fruits while, if detached from the plant they give rise to vegetative growth? A comparison of the behavior of the seed in the cluster of fruits with that in the fruit which has become incorporated in the plant body might give interesting information.

Any of these subjects can be easily investigated by persons with interest and intelligence. It would seem that the cactus fancier has plenty of interesting problems to work on besides simply amassing a collection of unique, grotesque, or ornamental cacti.

CULTIVATED FORMS

The following list contains the names of most of the cacti now in cultivation in the United States. Many other forms are to be found in collections, but they are not at all common. Those in the list are grouped with reference to their habits of growth. Measurements, where given, refer to mature plants and are only approximate. The list, arranged as it is with reference to size, will serve as a guide to prospective purchasers in dealing with collectors and traders.

The names used have been rearranged to accord with the latest monograph, which, on account of its recent publication and high cost, may not be available to most cactus growers and dealers. In order to make the lists more readily usable by those who do not possess the last work on the subject, the names in use up to and including Schumann's monograph (*22*) are given in parentheses. The same practice has been generally followed in the text.

COLUMNAR FORMS OF CACTI

Tall—more than 6 feet high

Carnegiea (*Cereus*) *gigantea.*
Cephalocereus (*Pilocereus*) *arrabidae* (*exerens*).
Cephalocereus (*Pilocereus*) *chrysacanthus.*
Cephalocereus (*Pilocereus*) *cometes.*
Cephalocereus (*Cereus*) *euphorbioides.*
Cephalocereus (*Pilocereus*) *hoppenstedtii.*
Cephalocereus (*Pilocereus*) *lanuginosus.*
Cephalocereus (*Pilocereus*) *leucocephalus* (*houlletii*).
Cephalocereus (*Pilocereus*) *nobilis* (*strictus*).
Cephalocereus (*Pilocereus*) *polylophus.*
Cephalocereus (*Pilocereus*) *russelianus.*
Cephalocereus (*Pilocereus*) *senilis.*
Cereus aethiops (*coerulescens*).
Cereus azureus.
Cereus columnaris.
Cereus forbesii (*validus*).
Cereus hildmannianus.
Cereus jamacaru.
Cereus peruvianus.
Cleistocactus baumanni.
Escontria chiotilla.
Lemaireocereus (*Cereus*) *dumortieri.*
Lemaireocereus griseus (*Cereus eburneus*).
Lemaireocereus (*Cereus*) *stellatus.*
Lemaireocereus (*Cereus*) *thurberi.*
Lemaireocereus (*Cereus*) *weberi.*
Lophocereus (*Pilocereus*) *schottii.*
Myrtillocactus (*Cereus*) *geometrizans.*
Nyctocereus (*Cereus*) *serpentinus.*
Opuntia cereiformis.
Pachycereus (*Cephalocereus*) *chrysomallus.*
Pachycereus (*Cereus*) *marginatus.*
Pachycereus (*Cereus*) *pectenaboriginum.*
Pachycereus (*Cereus*) *pringlei.*
Trichocereus (*Cereus*) *macrogonus.*

Lower—1 to 6 feet high

Astrophytum (Echinocactus) ornatum.
Bergerocactus (Cereus) emoryi.
Echinocactus ingens.
Echinocereus (Cereus) mammillatus.
Echinopsis eyriesi.
Ferocactus (Echinocactus) acanthodes (cylindraceus).
Ferocactus (Echinocactus) johnsonii.
Ferocactus (Echinocactus) nobilis (recurvus).
Ferocactus (Echinocactus) peninsulae.
Ferocactus (Echinocactus) stainesii (pilosus).
Heliocereus (Cereus) speciosus.
Machaerocereus (Cereus) eruca.
Machaerocereus (Cereus) gummosus.
Trichocereus (Cereus) candicans.
Trichocereus (Cereus) spachianus.
Trichocereus (Cereus) thelegonus.

Short—less than 1 foot high

Astrophytum (Echinocactus) capricornis.
Cochemiea (Mammillaria) halei.
Cochemiea poselgeri (Mammillaria roseana).
Cochemiea (Mammillaria) setispina.
Coryphantha (Mammillaria) clava.
Coryphantha (Mammillaria) cornifera.
Coryphantha (Mammillaria) erecta.
Coryphantha (Mammillaria) macromeris.
Coryphantha neo-mexicana (Mammillaria radiosa).
Echinocactus beguini.
Echinocactus bicolor.
Echinocactus krausei.
Echinocereus acifer.
Echinocereus blanckii (berlandieri).
Echinocereus chloranthus.
Echinocereus cinerascens.
Echinocereus coccineus (phoeniceus).
Echinocereus conglomeratus.
Echinocereus ctenoides.
Echinocereus dasyacanthus.
Echinocereus dubius.
Echinocereus engelmanni.
Echinocereus fendleri.
Echinocereus knippelianus.
Echinocereus mojavensis.
Echinocereus octacanthus (roemeri).
Echinocereus pectinatus.
Echinocereus pentalophus (procumbens).
Echinocereus rigidissimus.
Echinocereus (Echinocactus) scheeri.
Echinocereus stramineus.
Echinocereus triglochidiatus (paucispinus).
Echinocereus viridiflorus.
Echinofossulocactus (Echinocactus) anfractuosus.
Echinomastus (Echinocactus) intertextus.
Echinopsis (Echinocactus) leucantha.
Escobaria tuberculosa (Mammillaria strobiliformis).
Ferocactus (Echinocactus) hamatacanthus (longihamatus).
Ferocactus (Echinocactus) uncinatus.
Gymnocalycium (Echinocactus) gibbosum.
Malacocarpus (Echinocactus) leninghausii.
Mammillaria microthele.
Neolloydia (Mammillaria) conoidea.
Neolloydia clavata (Mammillaria raphidacantha).
Neomammillaria (Mammillaria) carnea.
Neomammillaria echinaria (Mammillaria gracilis).
Neomammillaria (Mammillaria) elegans.
Neomammillaria (Mammillaria) elongata.
Neomammillaria (Mammillaria) eriacantha.
Neomammillaria microcarpa (Mammillaria grahamii).
Neomammillaria pottsii (Mammillaria leona).
Neomammillaria (Mammillaria) spinosissima.
Neomammillaria tetracantha (Mammillaria dolichocentra).
Sclerocactus (Echinocactus) whipplei.

GLOBOSE FORMS OF CACTI

Large—more than 1 foot in diameter

Echinocactus grusoni.
Echinocactus ingens.
Ferocactus (Echinocactus) acanthodes.
Ferocactus (Echinocactus) hamatacanthus.
Ferocactus (Echinocactus) melocactiformis.
Ferocactus (Echinocactus) wizlizeni.

Medium—3 to 12 inches in diameter

Ariocarpus fissuratus.
Ariocarpus retusus.
Astrophytum (Echinocactus) capricornis.
Astrophytum (Echinocactus) myriostigma.
Cactus (Melocactus) macracanthus.
Cactus melocactus (Melocactus communis).
Coryphantha (Mammillaria) robustispina.
Coryphantha muehlenpfordtii (Mammillaria scheeri).
Coryphantha vivipara (Mammillaria radiosa).
Echinocactus heterochromus.
Echinocactus hexaedrophorus.
Echinocactus horizonthalonius.
Echinocactus lophothele.
Echinocactus polycephalus.
Echinofossulocactus (Echinocactus) albatus.
Echinofossulocactus (Echinocactus) coptonogonus.
Echinofossulocactus (Echinocactus) crispatus.
Echinofossulocactus (Echinocactus) multicostatus.
Echinomastus (Echinocactus) unguispinus.
Echinopsis multiplex.
Echinopsis oxygona.
Echinopsis turbinata (gemmata).
Ferocactus (Echinocactus) latispinus (corniger us).
Ferocactus (Echinocactus) robustus.
Hamatocactus (Echinocactus) setispinus.
Homalocephala (Echinocactus) texensis.
Leuchtenbergia principis.
Neomammillaria (Mammillaria) celsiana.
Neomammillaria (Mammillaria) gigantea.
Neomammillaria (Mammillaria) melanocentra.
Neomammillaria mystax (Mammillaria mutabilis).
Neomammillaria petterssonii (Mammillaria heeseana).
Neomammillaria (Mammillaria) seitziana.
Neoporteria (Echinopsis) nigricans.

Small—less than 3 inches in diameter

Ariocarpus kotschubeyanus.
Coryphantha (Mammillaria) elephantidens.
Coryphantha (Mammillaria) radians.
Coryphantha (Mammillaria) recurvata.
Dolichothele (Mammillaria) longimamma.
Dolichothele (Mammillaria) sphaerica.
Echinocactus humilis.
Echinomastus (Echinocactus) intertextus.

Echinomastus (*Echinocactus*) *macdowellii.*
Epithelantha (*Mammillaria*) *micromeris.*
Frailea (*Echinocactus*) *schilinzkyana.*
Gymnocalycium (*Echinocactus*) *denudatum.*
Gymnocalycium (*Echinocactus*) *schickendantzi.*
Lophophora lewinii.
Lophophora williamsii.
Malacocarpus (*Echinocactus*) *mammulosus.*
Malacocarpus (*Echinocactus*) *ottonis.*
Malacocarpus (*Echinocactus*) *submammulosus.*
Malacocarpus (*Echinocactus*) *tabularis.*
Mamillopsis (*Mammillaria*) *senilis.*
Mammillaria lesaunieri.
Neobesseya (*Mammillaria*) *missouriensis.*
Neomammillaria (*Mammillaria*) *bocasana.*
Neomammillaria (*Mammillaria*) *candida.*
Neomammillaria compressa (*Mammillaria cirrhifera*).
Neomammillaria (*Mammillaria*) *decipiens.*
Neomammillaria (*Mammillaria*) *dioica.*
Neomammillaria (*Mammillaria*) *elegans.*
Neomammillaria (*Mammillaria*) *formosa.*
Neomammillaria geminispina (*Mammillaria bicolor*).
Neomammillaria (*Mammillaria*) *gummifera.*
Neomammillaria (*Mammillaria*) *heyderi.*
Neomammillaria (*Mammillaria*) *lasiacantha.*
Neomammillaria magnimamma (*Mammillaria centricirrha*).
Neomammillaria (*Mammillaria*) *meiacantha.*
Neomammillaria (*Mammillaria*) *parkinsonii.*
Neomammillaria (*Mammillaria*) *perbella.*
Neomammillaria (*Mammillaria*) *plumosa.*
Ncomammillaria (*Mammillaria*) *polyedra.*
Neomammillaria prolifera (*Mammillaria pusilla*).
Neomammillaria (*Mammillaria*) *rhodantha.*
Neomammillaria (*Mammillaria*) *schelhasei.*
Neomammillaria (*Mammillaria*) *sempervivi.*
Neomammillaria (*Mammillaria*) *uncinata.*
Neomammillaria (*Mammillaria*) *wildii.*
Neomammillaria (*Mammillaria*) *zephyranthoides.*
Pediocactus (*Echinocactus*) *simpsoni.*
Pelecyphora aselliformis.
Pelecyphora pectinata.
Philosperma tetrancistia (*Mammillaria phellosperma*).
Rebutia (*Echinocactus*) *minuscula.*
Strombocactus (*Echinocactus*) *turbiniformis.*

PLATYOPUNTIAS AND NOPALEAS

Tall forms—more than 6 feet high

Nopalea auberi.
Nopalea coccinellifera.
Nopalea dejecta.
Opuntia amyclaea.
Opuntia brasiliensis (pl. 19, A).
Opuntia cacanapa.
Opuntia castillae.
Opuntia elatior.
Opuntia ficus-indica.
Opuntia gomei.
Opuntia leucotricha.
Opuntia monacantha.
Opuntia monacantha variegata.
Opuntia puberula.
Opuntia robusta.
Opuntia streptacantha.
Opuntia tomentosa.
Opuntia undosa.

Medium forms—2 to 6 feet high

Opuntia camanchica.
Opuntia chlorotica.
Opuntia curassavica.
Opuntia demissa.
Opuntia discata.
Opuntia ellisiana.
Opuntia engelmanni.
Opuntia inermis.
Opuntia lindheimeri.
Opuntia linguiformis.
Opuntia macrocalyx.
Opuntia macrocentra.
Opuntia microdasys.
Opuntia occidentalis.
Opuntia rufida.
Opuntia scheeri.
Opuntia stricta.

Low or decumbent forms—less than 2 feet high

Opuntia arenaria.
Opuntia basilaris (pl. 19, B).
Opuntia brachyclada.
Opuntia decumbens.
Opuntia fragilis.
Opuntia missouriensis.
Opuntia pes-corvi.
Opuntia procumbens.
Opuntia rutila.
Opuntia strigil.
Opuntia treleasei.
Opuntia ursina.
Opuntia vulgaris.

CYLINDROPUNTIAS

Tall forms—more than 6 feet high

Opuntia acanthocarpa.
Opuntia arborescens.
Opuntia arbuscula (pl. 12, B).
Opuntia cholla.
Opuntia cylindrica.
Opuntia echinocarpa.
Opuntia imbricata.
Opuntia spinosior.
Opuntia subulata.
Opuntia versicolor.
Opuntia vexans.

Medium forms—1 to 6 feet high

Opuntia alcahes.
Opuntia bernardina.
Opuntia bigelowi.
Opuntia deserta.
Opuntia fulgida.
Opuntia leptocaulis.
Opuntia mammillata.
Opuntia perrita.
Opuntia salmiana.
Opuntia tetracantha.
Opuntia tunicata.
Opuntia whipplei.

Low or prostrate forms—less than 1 foot high

Opuntia clava.
Opuntia davisii.
Opuntia diademata.
Opuntia emoryi.
Opuntia grahamii.
Opuntia parryi.
Opuntia schottii.

FOLIAGE-BEARING CACTI

Climbing or clambering forms

Pereskia aculeata.
Pereskia godseffiana.
Pereskiopsis brandegeei.
Pereskiopsis spathulata.

Shrubs or small trees

Pereskia amapola. *Pereskia bleo* (pl. 14, B). *Pereskia nicoyana.*

CLIMBING, NIGHT-BLOOMING FORMS OF CEREUS

Cereus pentagonus (*baxaniensis*).
Harrisia (*Cereus*) *bonplandi.*
Harrisia (*Cereus*) *martini.*
Harrisia (*Cereus*) *tortuosa.*
Hylocereus (*Cereus*) *ocamponis.*
Hylocereus (*Cereus*) *undatus* (*triangularis*).
Mediocactus (*Cereus*) *coccineus* (*setaceus*).
Selenicereus (*Cereus*) *boeckmanni* (*irradians*).
Selenicereus (*Cereus*) *grandiflorus.*
Selenicereus (*Cereus*) *hamatus.*
Selenicereus (*Cereus*) *macdonaldiae.*
Selenicereus (*Cereus*) *pteranthus* (*nycticalus*).
Selenicereus (*Cereus*) *spinulosus.*

PLANTS NATIVE TO MOIST TROPICAL REGIONS

Terrestrial

Phyllocactus ackermanni.
Phyllocactus acuminatus.
Phyllocactus anguliger.
Phyllocactus crenatus.
Phyllocactus grandis.
Phyllocactus hookeri.
Phyllocactus phyllanthoides.
Phyllocactus stenopetalus.
Phyllocactus strictus.

Epiphytic

Aporocactus (*Cereus*) *flagelliformis.*
Hariota salicornioides.
Lepismium cruciforme (*Rhipsalis anceps*).
Phyllocactus russellianus.
Rhipsalis cassytha.
Rhipsalis cereuscula (*saglionis*).
Rhipsalis grandiflora.
Rhipsalis houllittiana.
Rhipsalis mesembryanthemoides.
Rhipsalis paradoxa.
Rhipsalis pentaptera.
Rhipsalis rhombea.
Rhipsalis teres (*conferta*).
Schlumbergera (*Epiphyllum*) *gaertneri.*
Zygocactus (*Epiphyllum*) *truncatus.*

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